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Device for Machining of Components

The invention relates to a device for machining of components, namely for rotary machining of rotationally symmetrical components on radially interior machining surfaces of the components, according to the preamble of Patent Claim 1.

Rotors of gas turbines, especially rotors of high-pressure compressors of aircraft engines, are usually formed by several rotor disks arranged axially in succession, whereby the rotor disks are either bolted together or welded together. If the rotor disks are welded, welds formed on radially interior surfaces and radially exterior surfaces must be reworked to prevent notching. Since it is difficult to gain access to the radially interior surfaces of rotors, machining of welds on radially interior surfaces is more problematic than machining of welds on radially exterior surfaces.

In the course of the optimization of gas turbines, especially optimization of aircraft engines, higher and higher rotational speeds of the rotors are necessary. The load to be sustained by the rotors is also increased. As a rule, the hub bores inside the rotors are smaller, the higher the load on the rotors. It follows from this that the radial depth of chambers arranged between interconnected rotor disks increases. For example, if the radial depth of the chambers arranged between the interconnected rotor disks is greater than the diameter of the hub bore, special devices and/or tools are necessary for machining, namely for rotary machining, of the radially interior machining surfaces extending between the interconnected rotor disks.

Referring to prior art, devices and/or tools for rotary machining of rotors on radially interior machining surfaces taking into account the problems outlined above have been known. However, the devices and/or tools for rotary machining known from prior art are no longer suitable in particular if the width of the rotor disks in the hub area increases in addition to the progressively increasing radial depth of the chambers located between interconnected rotor disks, i.e., if the axial distance between two rotor disks is reduced in the hub area. In this case, it is impossible to insert the devices and/or tools known from prior art for rotary machining into the rotors to be machined and/or to perform any rotary machining on the radially interior machining surfaces of the rotor.

Against this background, the object of the present invention is to create a novel device for the machining of components.

This object is achieved in that the device mentioned in the beginning is improved upon by the features of the characterizing portion of the Patent Claim 1. According to this invention, the drill rod has a projection extending essentially radially, this projection being connectable with the tool mount extending essentially radially, whereby the radial dimensions of the projection on the bore rod and the tool mount are adapted to the dimensions of a hub bore of the component to be machined such that the drill rod and the tool mount can be inserted in the uncoupled state into the hub bore and in the coupled state the lathe tool mounted in the tool mount can be brought up to the radially interior machining surface of the component.

The present invention proposes a device for rotary machining of rotors on the radially interior machining surface of the rotors, said device even permitting reliable and secure machining of the radially interior machining surfaces of the rotors if, on the one hand, the diameter of the hub bores in the rotors to be machined is smaller and thus the radial extent of chambers located between two rotor disks inside the rotors to be machined is greater and if, on the other hand, the axial distance in the hub area, in particular between neighboring rotor disks which border chambers extending essentially in the radial direction, becomes smaller.

Preferred developments of the present invention are obvious from the subclaims and the following description. Exemplary embodiments of the invention are explained in greater detail below on the basis of the drawings without being limited thereto. They show in:

Fig. 1 a schematic illustration of an inventive device for rotary machining of rotationally symmetrical components on radially interior machining surfaces of the components, in plan view and in side view;

Fig. 2 the inventive device according to Fig. 1, in perspective view;

Fig. 3 a detail of the inventive device according to Fig. 1;

Fig. 4 another detail of the inventive device according to Fig. 1;

Fig. 5 another detail of the inventive device according to Fig. 1; and

Fig. 6 a schematic illustration of a device according to the prior art for rotary machining of rotationally symmetrical components on radially interior machining surfaces of the components in a sectional view.

The present invention is described in greater detail below with reference to Figs. 1 through 5. First, however, referring to Fig. 6, a device for rotary machining of rotationally symmetrical components on radially interior machining surfaces of same that is known from prior art is to be described.

Fig. 6 shows a cross-section through a rotor 10, e.g., for a high-pressure compressor of an aircraft engine. An axial axis of symmetry of the rotor 10 is labeled with reference numeral 11. The rotor 10 in Fig. 6 is formed by several rotor disks 12 arranged axially in succession, but only two such rotor disks 12 are shown in Fig. 6. The rotor disks 12 extend essentially in the radial direction, with two neighboring rotor disks 12 being joined together on radially exterior ends via projections 13 that extend axially. In the example shown in Fig. 6, the rotor disks 12 are joined by a weld 14 on the projections 13. To prevent notching, which causes a decline in strength, the rotor disks 12 welded together to the rotor 10 are reworked in the area of the welds 14. The device 15 shown in Fig. 6 for rotary machining is suitable for machining of the welds 14 on the radially interior machining surfaces 16 of the rotor 10.

The device 15 according to prior art has a drill rod 17 that extends essentially axially and a tool mount 18 that extends essentially radially. As Fig. 6 shows, the drill rod 17 of the device 15 is inserted into the hub bore of the rotor 10, but the tool mount 18 extends in the area of a chamber 19 formed between two rotor disks 12 that are joined together. A lathe tool 20 held in the tool

mount 18 comes into abutment with the radially interior machining surface 16 in the area of the projections 13 and ultimately is used for reworking the weld 14 on the radially interior machining surface 16. To do so, the rotor 10 is set in rotation, and the tool mount 18 and the lathe tool 20 are acted upon with a radial advance via the drill rod 17.

The device 15 known from prior art for rotary machining of the rotor 10 on the radially interior machining surfaces 16 as shown in Fig. 6 is no longer suitable for reworking the weld 14 in the area of the radially interior machining surfaces 16 if, as shown in Fig. 1, a hub area 21 of the rotor disks 12 of the rotor 10 becomes progressively thicker and thus the axial distance between two rotor disks 12 that are to be joined together in the hub area 21 is decreased. In this case, the device 15 shown in Fig. 6, which is known from the state of the art, namely the tool mount 18 of same rotor disks 12, can no longer be inserted into the chamber 19 between two interconnected rotor disks 12; on the other hand, due to the reduced axial spacing in the hub area 21 between two interconnected rotor disks 12, the device 15 according to prior art cannot provide an adequate axial advance for rotary machining.

Referring to Figs. 1 through 5, an inventive device 22 for rotary machining is described below, said device even permitting rotary machining of rotationally symmetrical components, in particular of rotors 10, when the geometric ratios of the rotor to be machined as described above and as shown in Fig. 1 prevail.

The inventive device 22 for rotary machining of rotationally symmetrical components on radially interior machining surfaces of the components has a drill rod 23 extending essentially axially and has a tool mount 24 extending essentially radially. The drill rod 23 extending essentially axially has a projection 25 extending essentially radially. The tool mount 24 can be affixed to the projection 25 on the drill rod 23. Fig. 1 shows a state of the inventive device 22, in which the tool mount 24 is attached to the projection 25 on the drill rod 23. Fig. 2, in contrast, shows a diagram in which the tool mount 24 is uncoupled from the projection 25 on the drill rod 23.

The radial dimensions of the projection 25 and/or the drill rod 23 and the radial dimensions of the tool mount 24 are adapted to the dimensions of a hub bore 26 of the rotor 10 to be machined such

that the drill rods 23 and the tool mount 24 can be inserted into the hub bore 26 in an uncoupled and/or disassembled state. One outside diameter of the tool mount 24 and of the drill rod 23, in particular the outside diameter of the projection 25 of same, is preferably smaller than one inside diameter of the hub bore 26. The tool mount 24 and the drill rod 23 may thus be inserted axially into the hub bore 26 of the rotor 10 to be machined, without the outside edges of the tool mount 24 and the drill rod 23 colliding with the inside edges of the rotor 10 to be machined. As shown in Fig. 3 in particular, the lathe tool 27 is set back radially with respect to an envelope of the tool mount 24. This makes it possible to reliably prevent damage to the rotor, in particular the rotor disks 12, on insertion of the inventive device 15 into the hub bore 26 of the rotor 10. In the assembled state, i.e., coupled state of the tool mount 24 and the projection 25 of the drill rod 23, a lathe tool 27 mounted in the tool mount 24 can be brought into contact with the radially interior machining surface 16 of the rotor 10 (see Fig. 1).

As shown in Figs. 2 and 3 in particular, the lathe tool 27, preferably designed as a rotary chisel, is mounted in the tool mount 24 by way of a lathe tool holder 28. The tool holder 28 can be pivoted with respect to the tool mount 24. The pivotability of the lathe tool holder 28 with respect to the tool mount 24 is illustrated by arrows in Fig. 1. The lathe tool 27 can be pivoted together with the lathe tool holder 28 with respect to the tool mount 24 and namely, in the sense of Fig. 1 with a primarily axial component. As shown best in Fig. 3, the lathe tool holder 28 is therefore mounted on the tool mount 24 via a rotary joint 30. The rotary joint 30 is formed by a bore inside the lathe tool holder 28 and by the tool mount 24 into which a bolt and/or a swiveling articulated pin 31 is inserted.

The pivoting movement of the lathe tool holder 28 with respect to the tool mount 24 is provided via a drive shaft 32 guided in the drill rod 23, whereby the drive shaft 32 is coupled to the lathe tool holder 28 via a gear 33. The gear 33 converts the drive movement, namely the rotational movement of the drive shaft 32 into a swiveling movement of the lathe tool holder 28.

In the exemplary embodiment shown here, the gear 33 is formed by several gearwheels arranged in the projection 25 of the drill rod 23. A first gearwheel 34 is operatively engaged with the drive

shaft 32 and a second gearwheel 35 is operatively engaged with a gearwheel 51, which is coupled to a worm gear 36, whereby the worm gear 36 is part of the gear 33 and is positioned in the tool mount 24. Referring to the exemplary embodiment of Fig. 3, another gearwheel 37 is connected between the first gearwheel 34, which is in contact with the drive shaft 32, and the second gearwheel 35, which is in contact with the gearwheel 51 of the worm gear 36. The rotational movement of the drive shaft 32 is thus transmitted via the gearwheels 34, 35, 37 and 51 to the worm gear 36, which is in operative connection with the lathe tool holder 28 and thus converts the rotational movement of the drive shaft 32 into a pivoting movement of the lathe tool holder 28. The gearwheels 34, 35, 37 and 51 and the worm gear 36 are mounted in the projection 25 of the drill rod 23 and/or in the tool mount 24 via corresponding bearing shafts 38. The lathe tool holder 28 is designed as a segment of a worm gear.

The drive power for driving the drive shaft 32 and thus ultimately the drive power for pivoting the lathe tool holder 28 are supplied either manually via a crank 39 or by an electric motor drive 40. The crank 39 and the electric motor drive 40 are depicted in Figs. 2 and 5. The crank 39 acts directly on the drive shaft 32. A gear 41 is connected between the electric motor drive 40 and the drive shaft 32. Fig. 5 shows a mechanical stop 42 that cooperates with the drive shaft 32, whereby the mechanical stop 42, together with the limit switches 43 and 44, limits the movement of the lathe tool holder 28 and thus the lathe tool 27, namely, the pivoting movement of same. Between the two limit switches 43 and 44, there is a switch 45 which serves to indicate the position of the lathe tool holder 28 and thus the lathe tool 27.

Fig. 3 shows lines 46 that are integrated into the drill rod 23, into the extension and/or the projection 25 on the drill rod 23 and into the tool mount 24 to carry coolant and/or lubricant, for example, in the direction of the lathe tool 27. The coolant and/or lubricant carried through the lines 46 is directed at the lathe tool 27 through a nozzle 47.

As already mentioned, the dimensions of the tool mount 24 and the projection 25 on the drill rod 23 are such that the tool mount 24 and the drill rod 23 in the disassembled and/or uncoupled state

can be inserted into the hub bore 26 of the rotor 10 to be machined. With the help of the assembly device 48 illustrated in Fig. 2, the tool mount 24 is first inserted into the hub bore 26 of the rotor 10 to be machined and is then axially shifted to the position inside the hub bore 26 and/or the rotor 10, where rotary machining is to be performed on radially interior surfaces of the rotor 10. In this axial position, the tool mount 24, together with the assembly device 48, is pushed radially outward between two neighboring rotor disks 12 of the rotor 10, i.e., into the chamber 19 between two neighboring rotor disks 12. Then the drill rod 23, together with the projection and/or projection 25, is pushed axially into the hub bore 26 of the rotor 10 to be machined until the projection 25 is in alignment with the tool mount 24. In this position, the tool mount 24 and the projection 25 of the drill mount 23 [sic] are joined together. This may be accomplished, for example, with the help of the clamping device 49 shown in Fig. 3. Alternatively, the tool mount 24 and the projection 25 of the drill rod 23 may also be coupled together by a screw connection.

As shown in Fig. 2 in particular, the inventive device 22 can be mounted to a machining station, namely to a tool carriage of a lathe via a quick-change mount 50. The quick-change mount 50 is thus an integral component of the drill rod 23.

With the inventive device, a rotary machining of a rotor on radially interior machining surfaces of the rotor is possible even when a hub bore of the rotor has a small radial extent in comparison with chambers that are connected on the outside radially to the hub bore and are bordered by two neighboring rotor disks. In addition, the inventive device is suitable for rotary machining of rotors when the axial distance between the rotor disks is minimal in the hub area of the rotor disks. The rotary machining of the rotor may also take place via the swiveling movement of the lathe tool when the small axial distance between two rotor disks does not allow an adequate axial advance of the drill rod. The pivoting movement of the lathe tool compensates for the lack of axial advance of the drill rod.